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ABSTRACT

The purpose of this study was to examine for the middle grades how students' cognitive reasoning level contributes to the variability of their achievement test performance. While previous investigations have indicated that measures of reasoning development are associated with measures of achievement, few such studies have attempted to control for differences in scholastic aptitude. In this particular investigation, the performance of 213 middle grades students on a test of formal reasoning was analyzed in relationship to scores on tests of achievement and scholastic aptitude. Results support cognitive reasoning as a significant determinant of achievement test performance when considered alone but not when controlling for scholastic aptitude. Results suggest that performance on reasoning tests is related to performance on achievement tests in a fashion very similar to performance on scholastic aptitude tests. Results further encourage middle grades educators to consider students' levels of reasoning when planning instruction. (Author/JAZ)

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Cognitive Reasoning as a Determinant of Achievement Test Scores in the Middle Grades

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Running Head: Cognitive Reasoning

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Abstract

The purpose of this study was to examine for the middle grades how students' cognitive reasoning level (e.g. concrete vs. formal reasoning ability) contributes to the variability of their achievement test performance. While previous investigations have indiciated that measures of reasoning development are associated with measures of achievement, few such studies have attempted to control for differences in scholastic aptitude. In this particular investigation, the performance of 213 middle grades students on a test of formal reasoning was analyzed in relationship to scores on tests of achievement and scholastic aptitude. Results support cognitive reasoning as a significant determinant of achievement test performance when considered alone but not when controlling for scholastic aptitude. Results suggest that performance on reasoning tests is related to performance on achievement tests in a fashion very similar to performance on scholastic aptitude tests. Results further encourage middle grades educators to consider students' levels of reasoning when planning instruction.

Cognitive Reasoning as a Determinant of Achievement Test Scores in the Middle Grades

The relationship between reasoning development and scholastic achievement has long been a critical question for educators. As Adelson (1983) notes, psychologists such as William James had identified the role of cognitive readiness in learning before the turn of the century. Other psychologists have repeatedly suggested that certain levels of intellectual growth are necessary for students to grasp abstract portions of the curriculum. In their theory of formal operations, Inhelder and Piaget (1958) proposed that reasoning develops through a series of stages from thinking about objects toward thinking about verbal propositions in the abstract.

Attempts to apply Piaget's theory to education have resulted in what Elkind (1976) has labelled a "developmental perspective," a growing recognition that children construct their own views of reality and that teachers need to design instruction that builds upon these views. Elkind (1980, 1983) further suggests that early adolescence is a critical period in the development of formal reasoning. He describes the abstract nature of many of the concepts taught in the middle grades and advocates instructional approaches that build abstractions incrementally. Instructional models such as Cognitive Levels Matching (Brooks, Fusco, & Grennon, 1984) provide specific approaches for assessing levels of reasoning and planning instruction accordingly.

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One of the basic tenets of a developmental perspective is that a student's level of reasoning plays a critical role in determining scholastic achievement. While theoretical support for such a position is very strong, empirical evidence of such a relationship is inconclusive. Reviewers such as Nagy and Griffith (1982) suggest that many investigations of relationships between reasoning development and achievement demonstrate serious methodological limitations. As a result, few definitive studies of such relationships are available to practitioners. Teachers need such information to better understand how students develop new modes of reasoning and how that development relates to scholastic tasks. The purpose of this study was to examine for the middle grades how students' cognitive reasoning level (e.g. concrete vs. formal reasoning ability) contributes to the variability of their achievement test performance.

Earlier investigations

While acknowledging the methodological complexities noted above, empirical studies have demonstrated some general linkages between reasoning development and achievement. Sullivan (1973) analyzed measures of arithmetic reasoning, critical thinking, reading, and scholastic aptitude in a sample of 526 students in the sixth and eighth grades. Scholastic aptitude and arithmetic reasoning were both significant contributors to reading scores and together accounted for nearly half the variation in both literal and critical reading comprehension. Sayre and Ball (1975) administered five interview tasks to 419 students in grades 7 through 12. While their classification procedures may have been limited, their results demonstrate a significant

relationship between students' levels of reasoning and the grades they received in their courses. Lawson, Norland, and Kahle (1975) administered similar interviews to students in grades 9 through 12 and found correlations of from .58 to .75 between formal tasks and scores on the Sequential Tests of Education Progress. Lawson (1982) reports intercorrelations among three measures of formal reasoning and five measures of achievement from a sample of 72 ninth grade students. The three measures of formal reasoning correlated significantly with reading (.61 to .69) language arts (.42 to .60), math (.53 to .70), social studies (.58 to .72), and science (.58 to .69). Tobin and Capie (1982) analyzed the relationships between formal reasoning ability, engagement modes, process skill achievement, and retention in 13 middle school science classes and found formal reasoning to be the strongest predictor of achievement and retention, accounting for 36 % of the variation in each case.

A wide range of related investigations have encouraged reviewers to draw tentative conclusions regarding reasoning development and achievement in the middle grades. In his review of studies of reading performance and reasoning development, Waller (1977) concludes that "mature reading comprehension is likely not possible without the ability to think operatively about written propositions in the abstract (p. 7)." Nagy and Griffith (1982) suggest that the research they reviewed "tends to show that there is a clear, but empirically weak link between developmental level and conceptual content (p. 543)."

Any conclusions regarding the linkages between reasoning development and achievement must be tempered with considerations of possible linkages between assessments of formal reasoning and measures of scholastic aptitude. Humphreys and Parsons (1979) reviewed a number of investigations of reasoning and scholastic aptitude. Their reanalysis of Stephens (1972) intercorrelations of Wechsler subtests, achievement tests, and Piagetian tasks clearly delineated the commonality of scholastic aptitude and Piagetian measures.

At least two studies with controls for differences in scholastic aptitude have demonstrated strong linkages between reasoning development and achievement however. Malone (1975) administered Piagetian task tests and reading achievement tests to 138 sixth and seventh grade students. Using a stratified random group procedure providing controls for effects of gender, age, grade level, and ability, scores on the operational tasks correlated significantly with reading scores. Lawson (1982) administered tests of formal reasoning, fluid intelligence, and biological achievement to 72 college students. The computed first order partial correlation coefficient, holding the fluid intelligence measure constant, between formal reasoning and achievement in biology was .51. These two studies support the hypothesis that reasoning development, independent of scholastic aptitude, is a factor that contributes to variation in achievement. The contradictory conclusions found in the research literature suggests careful scrutiny of scholastic aptitude relevant to an investigation of cognitive reasoning as a determinant of achievement.

One reason for the scarcity of rigorous investigations into the role played by cognitive level in determining achievement with middle grades populations has been the absence of appropriate group tests of reasoning development. As Nagy and Griffith (1982) suggest, accurate validation of such instruments is very difficult. Arlin (1982) reports a "multitrait-multimethod" validation of an instrument designed for use in the middle grades. Investigations to date that have used the Arlin Test of Formal Reasoning (1984) have yielded useful results. Bloland and Michael (1984) administered the Arlin test to 290 ninth and tenth grade students in algebra courses and found that the instrument provided a valid forecast of performance in beginning algebra when employed as a single predictor or in combination with another predictor such as a standardized math achievement test. Sherwood and Strahan (1985) report an investigation of developmental patterns of logical and creative thinking among 296 gifted students in grades 4 - 8. Scores on the Arlin Test of Formal Reasoning yielded correlations of .35 with mathematics achievement, of .19 with reading achievement, and of .27 with IQ.

Research to date thus suggests that measures of reasoning development are associated with measures of achievement but provides few precise analyses of these relationships. Most studies report only correlations and offer few insights about underlying relationships among factors. The contradictions noted regarding the role of scholastic aptitude as a factor suggest a need for more detailed analyses of the relationships between

measures. This particular study investigates the following hypotheses:

1) Cognitive reasoning level is a significant determinant of achievement test performance during the middle grades.

2) Cognitive reasoning level is a better predictor of achievement test performance than grade, age or sex of subjects during the middle grades.

3) Holding scholastic aptitude constant, cognitive reasoning level is a better predictor of achievement test performance than grade, age or sex of subjects during the middle grades.

Methodology

To test the causal-comparative research hypotheses, a multiple regression analysis was indicated which would examine the relative influences of cognitive reasoning level (ATFR), age (AGE), grade level (GRADE), gender (SEX) and scholastic aptitude (CSI) on achievement performance. An alpha level of .05 was set as a test of significance, given the exploratory nature of the study.

Sample:

An accessible middle school population was identified in a small city school district in North Carolina. In collaboration with the middle school's principal, a random cluster sample of 9 homeroom classes was selected. Three classes from each of the three grade levels within the school (6th, 7th, and 8th) participated in the study.

Data Collection:

In the spring of 1985, the Arlin Test of Formal Reasoning (1984) was administered to 213 students. During the administration of the Arlin Test of Formal Reasoning (ATFR) data was also collected about students' birthdate, grade level and sex. Other information relevant to the study was acquired through students' school records.

Within one month of administration of the ATFR to the students in the sample, scores on the California Achievement Test (CAT) from the April 1985 administration of the CAT were made available for all three grade levels. Twelve of the 213 students who had taken the ATFR had missing or incomplete CAT scores. Cognitive Skills Index (CSI) scores were available for 36 students in the 6th grade and 73 students in the 8th grade from the original sample of 213 students. The school district's policy is to administer the CSI in the spring for 5th and 8th graders. Eighth grade CSI scores were current with the CAT scores reported, whereas 6th grade CSI scores were taken from students' 5th grade records.

Measurement Instruments:

The Arlin Test of Formal Reasoning (1984) provides an estimate of students' level of reasoning based on written approximations of Piagetian interview items. Validation studies (Arlin, 1982) indicated high construct validity with interview assessments and reported test-retest reliabilities ranging from .76 to .89. Hoyt estimates of reliability range from .71 to .89. Raw score totals (number right) from 0 - 32 are equated to one of five cognitive levels (concrete, high concrete, transitional, low formal, high

formal).

Achievement test performance data was measured by the California Achievement Test, levels 16, 17, and 18; the first digit of the level corresponding to the currently enrolled grade during which it is administered. CAT scale scores were used in the analysis.

The Cognitive Skills Index is the scholastic aptitute measurement currently used by the school district. Level 3 is recommended for students between 5th and 7th grade and level 4 is for students in grades 7 - 9. According to the technical manual, concurrent validity estimates of the CSI with the Short Form Test of Academic Aptitude range from .81 to .83. Predictive validity estimates with the California Achievement test, levels 16 - 18, range from .82 to .86. CSI reliability estimates of internal consistency for levels 3 and 4 range from .81 to .87. CSI scores used in the analysis were normalized standard scores with a mean of 100 and a standard deviation of 16 based on students in a particular age group.

Results

The sample of 213 students in this investigation was composed of 102 boys and 111 girls and representative of three grade levels (67 sixth, 68 seventh, 78 eighth). Scores on the California Achievement Test indicate that the sample was not substantially different from the population of interest. Language mean scale scores for the selected 6th, 7th and 8th graders were respectively: 552, 580, and 583 in language; 495, 532, and 560 in math; and 532, 547, and 558 in reading. CSI scores

averaged 99 with a standard deviation of 18. Arlin reports the means and standard deviations for the middle school students who were used as a normative group as follows: 6th grade, mean = 12.06, SD = 3.74; 7th grade, mean = 13.24, SD = 4.14; and 8th grade, mean = 15.69, SD = 4.47. For the entire middle school grouping of 1484 students the mean is reported as 13.59 with a standard deviation of 4.31. Table 1 summarizes the descriptive data for the sample.

Zero order partial correlations with achievement were: ATFR (r=.493), AGE (r=-.075), GRADE (r=.358), SEX (r=.032) and CSI (r=.834). The regression analyses indicated that cognitive reasoning level (ATFR) when taken alone was a significant determinant (F=63.8, p<.0000) of achievement performance, accounting for 23.9% of the variation in achievement. When considered with AGE, GRADE, and SEX, cognitive reasoning level (ATFR) independently explains 12.7% of the variation in achievement while GRADE explains 22.9%; AGE explains 14.4%; and SEX independently explains none of the variation in achievement test performance.

A forward stepwise regression analysis of achievement with ATFR, AGE, GRADE and SEX, controlling for scholastic aptitude (CSI), reveals that GRADE is the only variable among the four that makes a significant (T=5.1, p<.0000) contribution to explaining an additional 6.4% of the variation in achievement.

Conclusions

In terms of the research hypotheses, the results of the study support cognitive reasoning level as a significant determinant of achievement test performance during the middle

grades. Also supported by the study is the hypothesis that cognitive reasoning level is a better predictor of achievement test performance than grade, age, or sex of subjects during the middle grades. Not supported by the study is the third hypothesis which states that holding scholastic aptitude constant, cognitive reasoning level is a better predictor of achievement test performance than grade, age or sex of subjects during the middle grades.

Results from this investigation suggest that performance on reasoning tests is related to performance on achievement tests in a fashion very similar to performance on scholastic aptitude tests. These results support the contention of Humphreys and Parsons (1979) that Piagetian tasks assess general aptitude as well as developmental levels of reasoning. Clearly, there is a need to explore further the connection between abstract reasoning and scholastic proficiency in the middle grades thereby providing teachers more information.

While differences between the sample and the normative population on the ATFR may limit the generalizability of this analysis, results reinforce the "develeopmental perspective" advocated by Elkind (1980) and other middle grades educators. Average ATFR scores for this group fell in the "high concrete" level and few students at any grade had scores in the "transitional" or "formal" levels. This comparatively low frequency of students who score at formal reasoning levels combined with the linkages between such reasoning and achievement strongly support the recommendation that teachers attempt to

identify the reasoning levels of their students and develop instructional strategies to help students generate abstract concepts in the content areas.

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Table 1.

Student Sample Descriptive Data

	Number M/F Children	Mean Age	California Achievement Test (scale scores) Mean Reading (SD)	Mean Language (SD)	Mean Math (SD)	Mean Arlin (SD)
6th Grade	32/35 67	12.3	502 (71.7)	552 (73.9)	495 (58.6)	9.7 (3.5)
7th Grade	30/38 68	13.1	547 (55.3)	580 (44.1)	532 (53.8)	11.1 (4.0)
8th Grade	40/38 70	14.0	558 (63.7)	583 (55.7)	560 (54.5)	11.2 (3.8)
Total Sample	102/111 213	13.1	537 (67.9)	572 (60.3)	529 (61.7)	10.7 (3.8)